

# Moscovian (Carboniferous) orthoconic cephalopods from Guizhou and Guangxi, South China

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**Abstract.** Nine species of orthoconic cephalopods have been described from Moscovian (Carboniferous) limestone of the Guizhou and Guangxi region, South China. The fauna is composed of four orthocerids: *Bogoslovskya guizhouensis* sp. nov., *Merioceras guangxiense* sp. nov., *Merioceras* sp., and *Mimogeisonoceras* ? sp. and five bactritids: *Bactrites faqingensis* sp. nov., *Bactrites* cf. *nagatoensis* Niko, Nishida and Kyuma, *Bactrites* sp., *Ctenobactrites* ? sp., and *Sinobactrites wuae* gen. et sp. nov. The new parabactritid genus *Sinobactrites* is diagnosed by its relatively small angle of shell expansion, oval cross section, and abruptly recurved septal necks. It is noteworthy that the assemblage includes species closely related to some of the Akiyoshi fauna.

**Key words:** Bactritida, Moscovian, Orthocerida, South China

## Introduction

During most of the Late Paleozoic Era, South China (Yangtze platform) was located in tropical to subtropical zones (Scotese and McKerrow, 1990; Zhang and Yan, 1993). A thick Carboniferous sequence, dominated by limestones and dolomites, is widely developed in the Yunnan, Guizhou, and Guangxi region, and has provided important information to biozonation schemes using fusulinids, brachiopods, corals (Wu *et al.*, 1974), and ammonoids (Yang, 1978) in low-latitude waters. In contrast, knowledge of orthoconic cephalopods of South China has remained insufficient. As far as we know, only four (or five?) orthocerid species and a single species of actinocerid have been reported in Visean strata of the area (Lai, 1964; Liang and Zhu, 1988). It is the purpose of this report to describe Carboniferous orthoconic cephalopods from Faqing of the Riupansui area, Guizhou Province (see text-fig. 2 in Nishida *et al.*, 1996) and Balai of the Riucui area, Guangxi Zhuangzu Autonomous Region (Figure 1). The cephalopods described herein occur in light-gray bioclastic limestone with the following associated fusulinids: *Fusulinella* cf. *pseudobocki* (Lee and Chen) in Faqing, and *Fusulinella bocki* Möeller and *F.* cf. *pseudobocki* in Balai. Nishida *et al.* (1996) stated that the cephalopod-bearing rocks belong to the Dala (Huanglong) Formation and can be correlated with strata of the lower Upper Carboniferous Moscovian Stage. The type specimens are deposited in the geological collections of Saga University (GS).

## Systematic paleontology

Class Cephalopoda Cuvier, 1797  
Subclass Nautiloidea Agassiz, 1847  
Order Orthocerida Kuhn, 1940  
Superfamily Orthocerataceae M'Coy, 1844  
Family Orthoceratidae M'Coy, 1844  
Subfamily Michelinoceratinae Flower, 1945  
Genus *Bogoslovskya* Zhuravleva, 1978

*Type species.*—*Bogoslovskya perspicua* Zhuravleva, 1978.

*Bogoslovskya guizhouensis* sp. nov.

Figures 2–13

*Diagnosis.*—Species of *Bogoslovskya* with approximately 8–10 degrees angle of shell expansion, weak lateral compression in cross section, transverse lirae-ribs; adoral cameral ratio 2.8–3.9; minimum distance of central axis of siphuncle from shell surface per dorsoventral diameter approximately 0.22 in adoral shell.

*Description.*—Orthocones with rapid shell expansion for genus, angle ranges from 8.1 to 10.0 degrees; cross section of shell laterally compressed weakly, lateral/dorsoventral ratio 0.92 in holotype; largest specimen (GS.C145) of phragmocone reaches 15.1 mm in dorsoventral diameter; juvenile shells (up to 4–5 mm dorsoventral diameter) lack surface



Figure 1. Index map of fossil locality on the southwestern foot of small conical mountain called Balai in Guangxi, South China.

ornamentation, then anti-siphuncular (dorsal?) shell surface marks begin with straight, transverse but slightly oblique (toward aperture on anti-siphuncular side) lirae, which diminish toward siphuncular side and possess periodic, well prominent ridges; these ridges become distinct adorally, forming slightly sinuate ribs; however, ornamentation becomes faint again in most adoral shell (dorsoventral shell diameter approximately 15 mm); sutures straight, directly transverse to slightly oblique; septal curvature moderate; cameral length short for genus, 2.3–3.7 mm in adoral shell of holotype, cameral ratio (dorsoventral diameter/length) 2.8–3.9; siphuncle narrow, maximum diameter of septal neck/dorsoventral shell diameter approximately 0.06, submarginal position, minimum distance of central axis of siphuncle from shell surface per dorsoventral shell diameter ranges from 0.21 to 0.23 in holotype at dorsoventral shell diameter of approximately 10–12 mm; septal necks gently tapering orthochoanitic, forming funnel shape, neck length 1.0 mm at dorsoventral shell diameter of 12.3 mm of holotype; weak auxiliary deposits recognized in septal foramina; connecting rings not preserved; no cameral deposits detected.

**Discussion.**—*Bogoslowskya guizhouensis* sp. nov. is closely similar to *B. akiyoshiensis* Niko, Nishida and Kyuma (1995, figs. 1–1–14) described from the Moscovian of the Akiyoshi Limestone, Southwest Japan. It differs from the Akiyoshi

species by the larger angle of shell expansion (approximately 8–10 degrees vs. approximately 7 degrees in *Bogoslowskya akiyoshiensis*), the well-developed surface ornamentation, and the less eccentric siphuncular position; i.e. ratio of the minimum distance of the central axis of the siphuncle from shell surface per the dorsoventral diameter is approximately 0.22 vs. 0.19 in *B. akiyoshiensis* in the corresponding shell diameter.

The surface ribs are also recognized in the Gzhelian to Asselian species *Bogoslowskya miharanoroensis* Niko and Ozawa (1997, figs. 2–1–9) from the Taishaku Limestone, Southwest Japan. However, *B. miharanoroensis* is evidently distinguished from the new species by the narrower shell (angle of shell expansion 4–5 degrees) and the well-developed ribs even in the adoral shell.

This new species is the most abundant cephalopod in the Dala (Huanglong) Formation. To date 44 specimens, which account for approximately 72 per cent of all examined orthoconic cephalopods, have been obtained. The swarmed occurrence is also known in *Bogoslowskya akiyoshiensis*.

**Etymology.**—The specific name is derived from the provincial name of the type locality, Guizhou.

**Material and occurrence.**—The holotype, GS.C128, is an incomplete phragmocone, 24.0 mm in length. The following 11 paratypes of fragmentary phragmocones are assigned: GS.C129, 144–147, 156–159, 167, 170. In addition, 32 reference specimens, GS.C127, 130–143, 148–155, 160–166, 168, 169, were also examined. All specimens were collected from Faqing.

#### Genus *Mericoceras* Zhuravleva, 1978

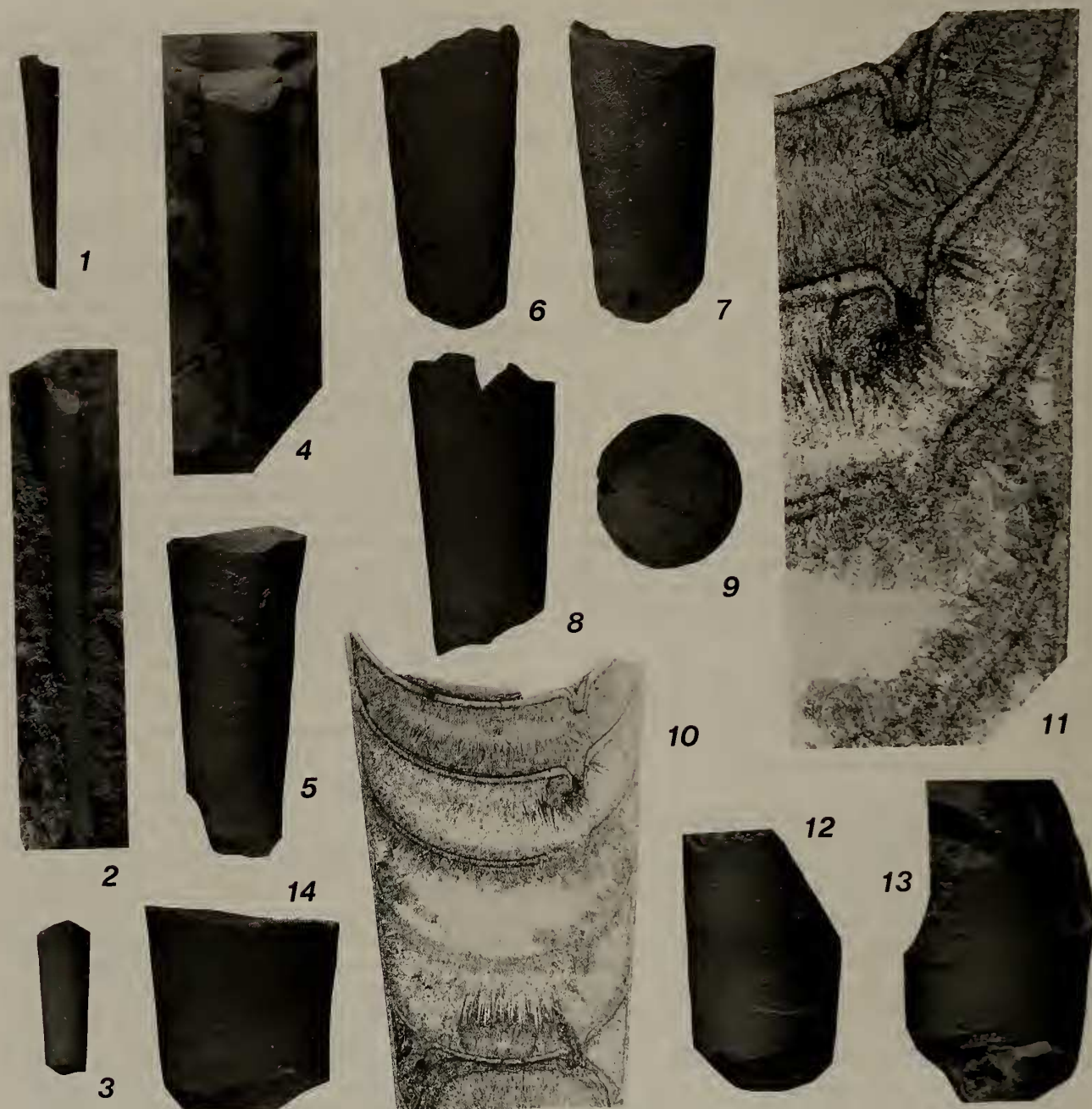
**Type species.**—*Mericoceras karagandense* Zhuravleva, 1978.

#### *Mericoceras guangxiense* sp. nov.

Figures 3–4–6

**Diagnosis.**—Species of *Mericoceras* with angle of shell expansion approximately 7 degrees; cameral ratio 2.2–2.4; siphuncle with weak constrictions at septal foramina.

**Description.**—Single orthoconic phragmocone with moderate to relatively rapid shell expansion, angle 7.3 degrees (reconstructed from slightly deformed shell) in adoral portion of shell; cross section of shell circular, reaches approximately 19 mm (reconstructed) diameter; surface ornamentation of reticulated pattern composed of transverse and longitudinal lirae, transverse lirae wider and more prominent than longitudinal lirae, form salients in adoral shell; sutures nearly transverse; septal curvature moderate to relatively deep; cameral length 6.1–7.4 mm in adoral shell, giving cameral ratio 2.2–2.4; siphuncle central in position, siphuncular diameter/corresponding shell diameter 0.13–0.15, free of endosiphuncular deposits; septal necks short, weakly recurved suborthochoanitic to orthochoanitic, 0.7–1.0 mm in length at shell diameter of approximately 18 mm (reconstructed), connecting rings thin, cylindrical with weak constrictions at septal foramina; cameral deposits not observed.



**Figure 2.** *Bogoslovskya guizhouensis* sp. nov. 1. Paratype, GS.C146, side view of early juvenile shell. 2. Paratype, GS.C147, side view of early juvenile shell. 3. Paratype, GS.C167, lateral view of juvenile shell, siphuncular side on right. 4. Paratype, GS.C144, lateral view of juvenile shell, siphuncular side on right. 5. Paratype, GS.C157, anti-siphuncular view. 6-11. Holotype, GS.C128, 6: anti-siphuncular view, 7: siphuncular view, 8: lateral view, siphuncular side on right, 9: septal view of adoral end, siphuncular side down, 10: dorsoventral thin section, 11: details of adoral siphuncle. 12. Paratype, GS.C170, lateral view, siphuncular side on left. 13. Paratype, GS.C156, anti-siphuncular view. 14. Paratype, GS.C145, lateral view, siphuncular side on left. 1, 2, 10 =  $\times 4$ , 3-9, 12-14 =  $\times 2$ , 11 =  $\times 10$ .

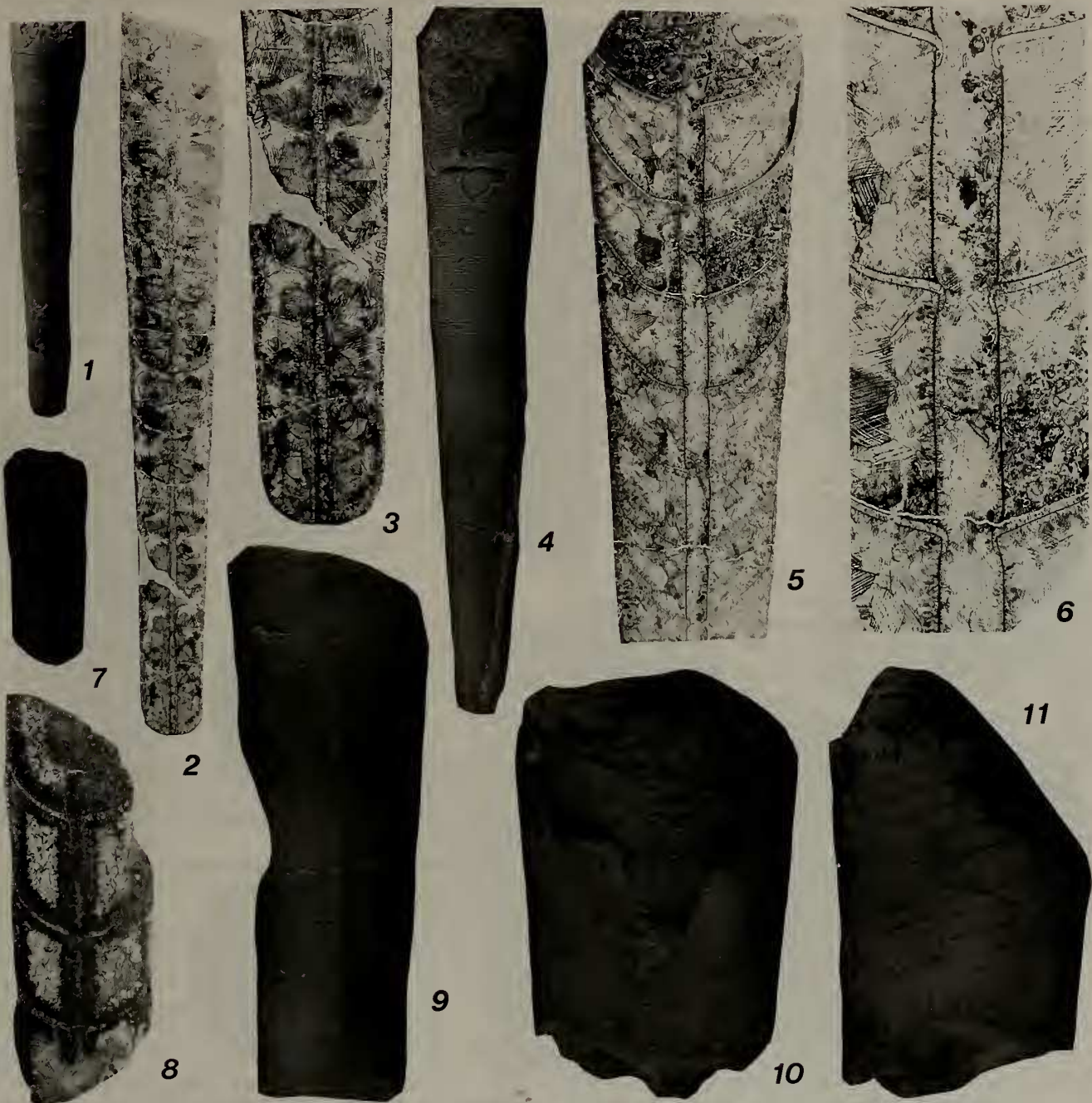


Figure 3. 1-3. *Merioceras guangxiense*?, GS.C124, 1: side view, 2: longitudinal thin section, 3: details of apical shell. 4-6. *Merioceras guangxiense* sp. nov., holotype, GS.C125, 4: side view, 5: longitudinal thin section of adoral shell, 6: details of adoral siphuncle. 7, 8. *Merioceras* sp., GS.C126, 7: anti-siphuncular view, 8: dorsoventral thin section. 9. *Bactrites* cf. *nagatoensis* Niko, Nishida and Kyuma, GS.C178, dorsal view. 10, 11. *Ctenobactrites*? sp., GS.C183, 10: dorsal view, 11: lateral view, venter on left. 1= $\times 3$ , 2, 6= $\times 5$ , 3= $\times 10$ , 4, 10, 11= $\times 1$ , 5, 7, 9= $\times 2$ , 8= $\times 4$ .

*Discussion.*—The possession of reticulate surface ornamentation consisting of lirae is relatively rare for orthoconic cephalopods, but recognized through several families, such as Orthoceratidae, Geisonoceratidae, and Pseudorthoceratidae. The siphuncular structure mentioned above suggests that the cephalopod is a species of the orthoceratid genus *Mericoceras* Zhuravleva (1978). The type species, *Mericoceras karagandense* Zhuravleva (1978, pl. 4, figs. 1–4), from the Famennian (Upper Devonian) of central Kazakhstan, was previously the only species definitely assigned to the genus. Slightly larger angle of adoral shell expansion (approximately 7 degrees vs. 4–6 degrees in *Mericoceras karagandense*) and the possession of weak constriction at septal foramina of the Carboniferous species are considered as difference of specific rank.

*Etymology.*—The specific name is derived from the Autonomous Region name of the type locality, Guangxi.

*Material and occurrence.*—The holotype, GS.C125, is an incomplete phragmocone, 108.5 mm in length. The specimen was collected from Balai.

***Mericoceras guangxiense* Niko, Nishida and Kyuma ?**

Figures 3–1–3

*Discussion.*—In addition to the holotype described above a phragmocone questionably assigned to *Mericoceras guangxiense* sp. nov. was also examined. The specimen is an orthoconic shell with circular cross section, reticulate surface ornamentation, *Michelinoceras*-like siphuncular structure and mural deposits. It may represent the juvenile portion of *Mericoceras guangxiense*. However, lack of intermediates between the holotype and this specimen prevents a positive assignment.

Internally and externally siphuncle of this specimen is covered with thin carbonate. Judging from position and uniform thickness of the deposits, we consider that they are of diagenetic origin.

*Material and occurrence.*—GS.C124 from Balai.

***Mericoceras* sp.**

Figures 3–7, 8

*Description.*—Single incomplete phragmocone of orthoconic shell with circular cross section, weak reticulate surface ornamentation; angle of shell expansion approximately 4 degrees; siphuncle subcentral with orthochoanitic necks and cylindrical connecting rings; no cameral and/or endosiphuncular deposits detected.

*Discussion.*—The species differs from *Mericoceras guangxiense* sp. nov. in its subcentral siphuncular position, but this is insufficient for a specific identification.

Niko et al. (1987) illustrated an ill-preserved Moscovian orthocerid as *Striacoceras* ? sp. from the Akiyoshi Limestone. The combination of reticulate surface ornamentation and the orthochoanitic septal necks suggests that the species probably falls within the genus *Mericoceras*. With the exception of the siphuncular position, both species share diagnostic morphology.

*Material and occurrence.*—GS.C126 from Faqing.

**Genus *Mimogeisonoceras* Shimanskiy, 1968**

*Type species.*—*Mimogeisonoceras ljubovae* Shimanskiy, 1968.

***Mimogeisonoceras* ? sp.**

Figure 4–11

*Description.*—Single incomplete phragmocone of orthoconic shell with circular cross section, gradual shell expansion; surface ornamentation of transverse, slightly sinuate grooves with very deep salient; siphuncular position central.

*Discussion.*—The species shares the characteristic ornamentation with *Mimogeisonoceras ljubovae* Shimanskiy (1968, pl. 1, fig. 3) from the Namurian of the Southern Urals, but the shell is more slender than that of *M. ljubovae*. It is represented by a single fragment of the probably juvenile portion. Thus, the generic assignment is tentative.

*Material and occurrence.*—GS.C171 from Faqing.

Subclass Bactritoidea Shimanskiy, 1951

Order Bactritida Shimanskiy, 1951

Family Bactritidae Hyatt, 1884

Genus *Bactrites* Sandberger, 1843

*Type species.*—*Bactrites subconicus* Sandberger, 1843.

***Bactrites faqingensis* sp. nov.**

Figures 4–1–7

*Diagnosis.*—Species of *Bactrites* with approximately 7–8 degrees angle of shell expansion, circular cross section; surface ornamentation transverse dense lirae; cameral ratio 1.8–2.5.

*Description.*—Orthocones with relatively rapid shell expansion for genus, angle 7.1–8.4 degrees; cross section of shell circular; largest specimen (holotype) attains 16.6 mm in diameter at portion of last septum; preserved body chamber 29.9 mm in length; shell surface marked by transverse dense lirae that are slightly oblique towards aperture on dorsal side; excepting ventral lobe sutures directly transverse, straight; septa deeply concave with wide mural portion; cameral length moderate, 6.2–7.4 mm, its ratio 1.8–2.5 in holotype at shell diameter approximately 13–16 mm; siphuncular position ventral margin; septal necks orthochoanitic in dorsum, 1.0 mm in length at last septum of holotype; ventral septa attached to shell wall in dorsoventral section with weak projections at septal foramina; minimum diameter of septal foramen/shell diameter in holotype approximately 0.05; connecting rings not preserved; lacks cameral and/or endosiphuncular deposits.

*Discussion.*—This species is easily distinguished from most known Carboniferous species of *Bactrites* by its surface ornamentation of transverse dense lirae. Only *Bactrites costatus* Mapes (1979, pl. 31, figs. 7–9, 13), from the Virgilian of Texas, possesses similar surface ornamentation. However,

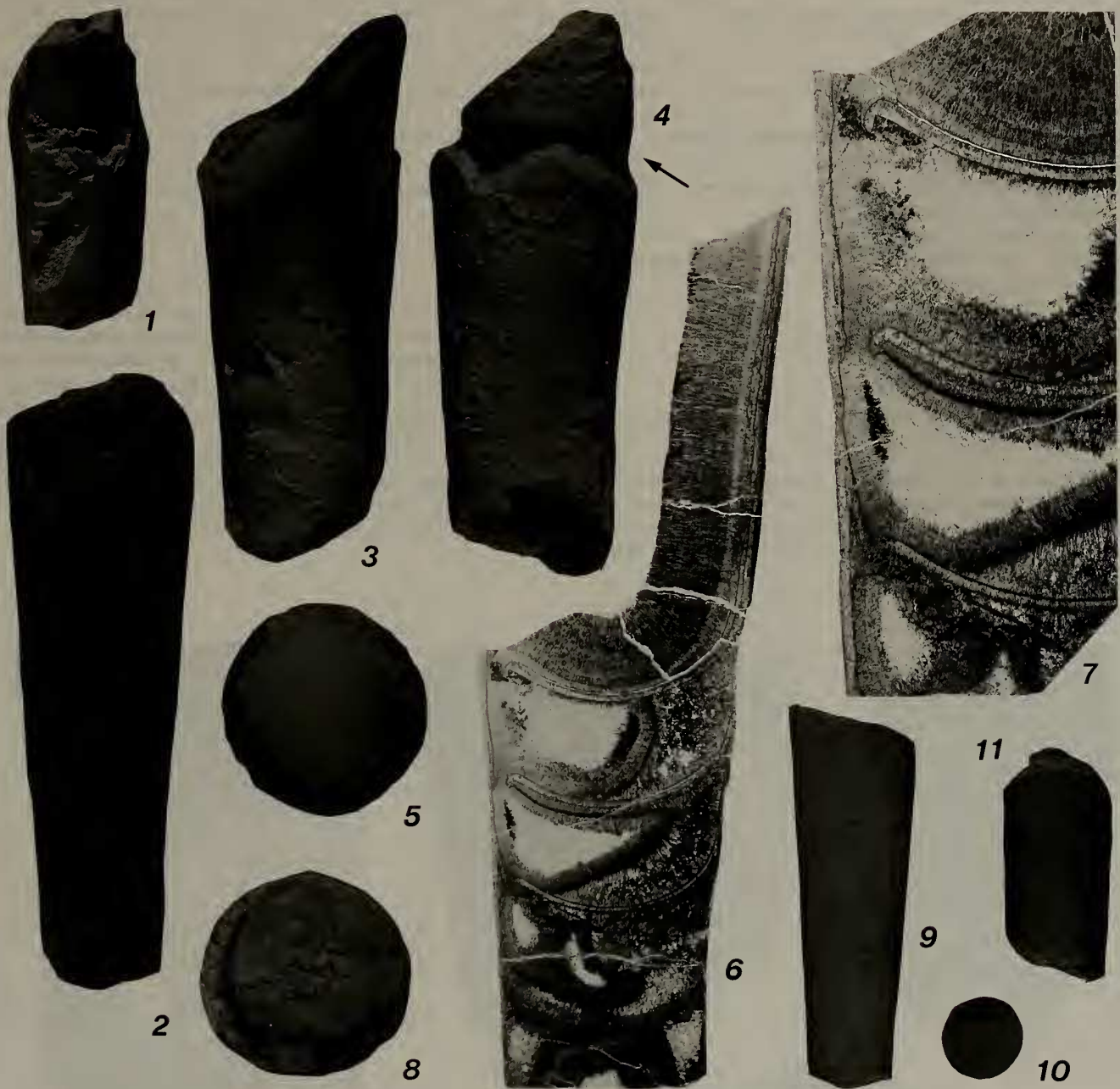


Figure 4. 1-7. *Bactrites faqingensis* sp. nov., 1: paratype, GS.C174, lateral view, venter on left, 2: paratype, GS.C173, ventral view, 3-7: holotype, GS.C172, 3, lateral view, venter on left; 4, ventral view, arrow indicates position of the last septum; 5, septal view of the last septum, venter down; 6, dorsoventral thin section; 7, details of adoral siphuncle. 8. *Bactrites* cf. *nagatoensis* Niko, Nishida and Kyuma, GS.C178, adoral end, venter down. 9, 10. *Bactrites* sp., GS.C181, 9: lateral view, venter on right, 10: septal view of apical end, venter down. 11. *Mimogeisonoceras* ? sp., GS.C171, side view. 1-5, 8-10 =  $\times 2$ , 6 =  $\times 2.5$ , 7 =  $\times 5$ , 11 =  $\times 4$ .

it has longer camerae (cameral ratio 1.2-1.7 vs. 1.8-2.5) and a somewhat narrower shell (angle of expansion 5-7 degrees vs. approximately 7-8 degrees) than does *Bactrites faqingensis*.

*Etymology*.—The specific name is derived from the type locality name, Faqing.

*Material and occurrence*.—The holotype, GS.C172, is an incomplete phragmocone with apical body chamber, 63.7 mm in length. The following two paratypes of incomplete phragmocones are assigned: GS.C173, 174. In addition, three fragmentary specimens, GS.C175-177, were also examined. All specimens were collected from Faqing.

*Bactrites* cf. *nagatoensis* Niko, Nishida and Kyuma, 1991

Figures 3-9; 4-8

cf. *Bactrites nagatoensis* Niko, Nishida and Kyuma, 1991, p. 715, figs. 2-1-10, 3-1-5.

*Description*.—Orthocones with moderate shell expansion, angle of expansion approximately 6 degrees; cross section of shell circular; largest specimen (GS.C179) attains approximately 22 mm (reconstructed) diameter; a single dorsal

carina strongly developed, shell surface lacks other ornamentation; septal and siphuncular morphology not observed.

*Discussion*.—This species bears a close resemblance in its shell shape and ornamentation to *Bactrites nagatoensis* from the Moscovian (Kyuma and Nishida, 1992) of the Akiyoshi Limestone, but its internal structure needs to be examined.

*Material and occurrence*.—GS.C178, 179 from Faqing.

*Bactrites* sp.

Figures 4-9, 10

*Description*.—Orthocones with relatively rapid shell expansion, angle approximately 8 degrees; largest specimen (GS.C181) attains 9.8 mm in diameter; cross section of shell circular; shell surface lacks ornamentation; sutures transverse, but form weak sinuation and ventral lobe; siphuncular position ventral margin.

*Discussion*.—The specimens may represent immature shells. Inadequate knowledge of morphology prevents comparison at the specific level.

*Material and occurrence*.—GS.C180-182 from Faqing.

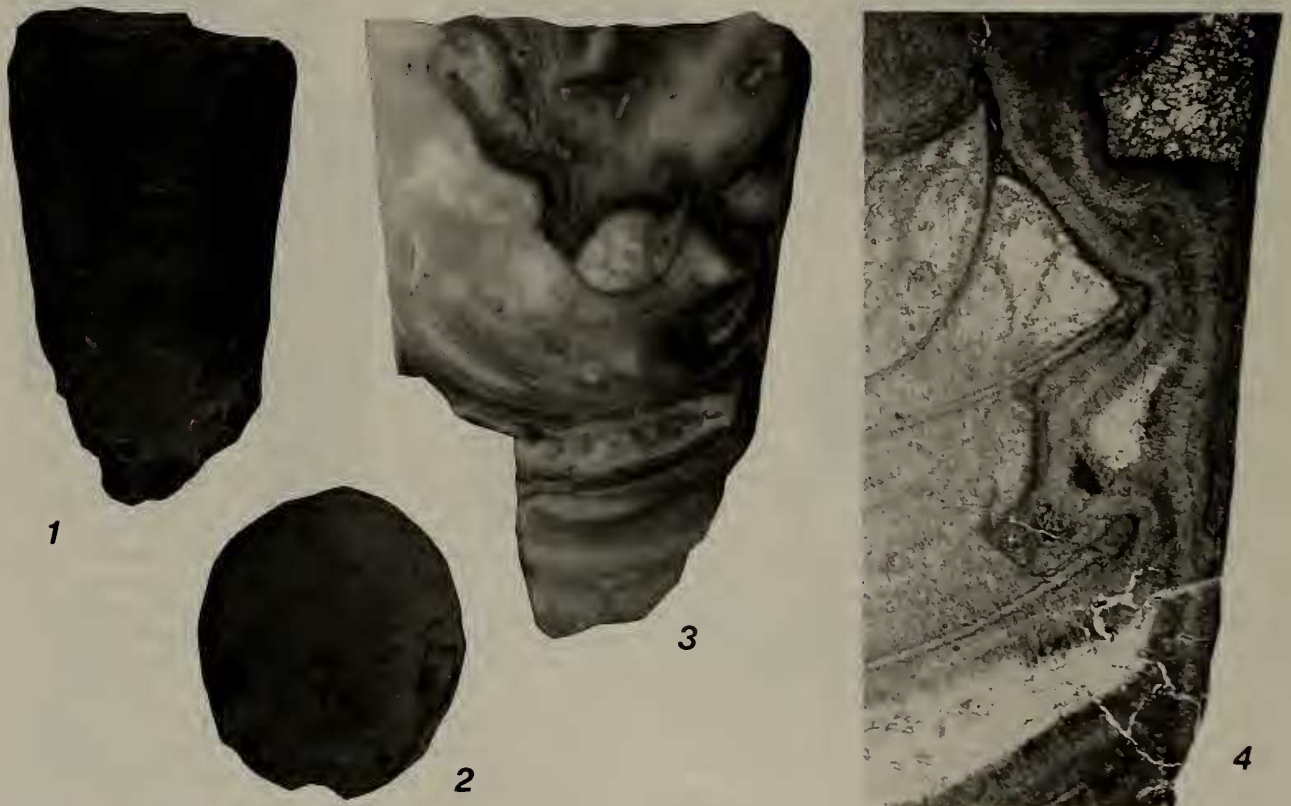


Figure 5. *Sinobactrites wuae* gen. et sp. nov., holotype, GS.C184. 1. Lateral view, venter on right. 2. Adoral end, venter down. 3. Dorsoventral polished section, venter on right. 4. Dorsoventral thin section, showing details of siphuncle. 1, 2 =  $\times 1$ , 3 =  $\times 1.5$ , 4 =  $\times 4$ .

Genus *Ctenobactrites* Shimanskiy, 1951

## Family Parabactritidae Shimanskiy, 1951

Genus *Sinobactrites* gen. nov.

Type species.—*Ctenobactrites costatus* Shimanskiy, 1951.

*Ctenobactrites* ? sp.

Figures 3–10, 11

*Description*.—Single large-sized orthocone with circular cross section, having maximum diameter of approximately 43 mm (reconstructed); shell surface ornamented by flat-topped wide ribs that form broad, but shallow ventral sinus and dorsal saddle, each rib ranges from 2.5 to 3.0 mm in width; grooves separating ribs narrow; septal and siphuncular morphology not observed.

*Discussion*.—The lack of internal structure of the present specimen hinders confident taxonomic assignment. However, the characteristic rib form suggests a relationship to *Ctenobactrites*. The surface ornamentation of this species somewhat resembles *Ctenobactrites* spp. from the Virgilian of Texas (Mapes, 1979, pl. 23, figs. 1, 2) and the Moscovian of the Akiyoshi Limestone (Niko *et al.*, 1991, figs. 3–10, 11).

*Material and occurrence*.—GS.C183 from Faqing.

Type species.—*Sinobactrites wuae* sp. nov., by monotypy.

*Diagnosis*.—Breviconic orthocone with relatively small angle of expansion for family, approximately 15 degrees; cross section of shell laterally compressed; shell surface smooth; siphuncle marginal, relatively large; septal necks abruptly recurved, brims in contact with posterior surface of septa.

*Etymology*.—The generic name is derived from *Sino* (combining form of the Latin *Sinae*, meaning Chinese), and *Bactrites*.

*Sinobactrites wuae* sp. nov.

Figures 5–1–4, 6

*Diagnosis*.—As for the genus.

*Description*.—Single large-sized breviconic orthocone, angle of shell expansion relatively small for family, 14.8 degrees in dorsoventral plane; cross section of shell laterally compressed, oval; adoral end attains 41.6 mm in dorsoventral diameter and 35.1 mm in lateral diameter, giving form ratio 0.84; shell surface smooth, lacks conspicuous ornamentation; sutures rectilinear except for ventral lobe; septal curvature moderate to relatively deep for the family; camerae short, cameral ratio in dorsoventral section 0.2; siphuncular position ventral margin; siphuncle relatively large, minimum diameter of septal foramen/shell diameter in dorsoventral section approximately 0.07; dorsal septal necks abruptly recurved and septal brims in contact with posterior surface of septa, brim length 1.6–2.0 mm in approximately 31 (reconstructed)–38 mm in dorsoventral shell diameter; septa on ventral side of siphuncle in contact with shell wall in dorsoventral plane with weak projections at septal foramina; connecting rings not preserved; lacks any evidence of cameral and/or endosiphuncular deposits.

*Discussion*.—The abruptly recurved septal necks of *Sinobactrites wuae* gen. et sp. nov. are also recognized in *Belemnitomimus palaeozoicus* Shimanskiy (1954, pl. 12, figs. 1, 2; type species of the genus) from the Lower Permian of the Southern Urals. However, *Belemnitomimus* can be clearly distinguished from the new genus by its much greater shell expansion (approximately 30 degrees vs. approximately 15 degrees in *Sinobactrites wuae*), the circular cross section of the shell, and the well prominent ventral septa.

The Permian genus *Microbactrites* Shimanskiy (1954, type species, *Parabactrites scorobogatovae* Shimanskiy, 1948, fig. 2) from the Southern Urals has somewhat similar shell shape to *Sinobactrites*. Although the siphuncular structure of *Microbactrites* is not illustrated by Shimanskiy, the genus is clearly distinguished from *Sinobactrites* in having oblique folds in the shell surface.

The geographic distribution of parabactritids was previously restricted to the Southern Urals (Shimanskiy, 1948, 1954, 1968), Pamirs (Shimanskiy, 1993), and the Taishaku Limestone (Niko *et al.*, 1993). Thus, the Chinese species extends the range of the family. In addition, pre-Permian undoubted

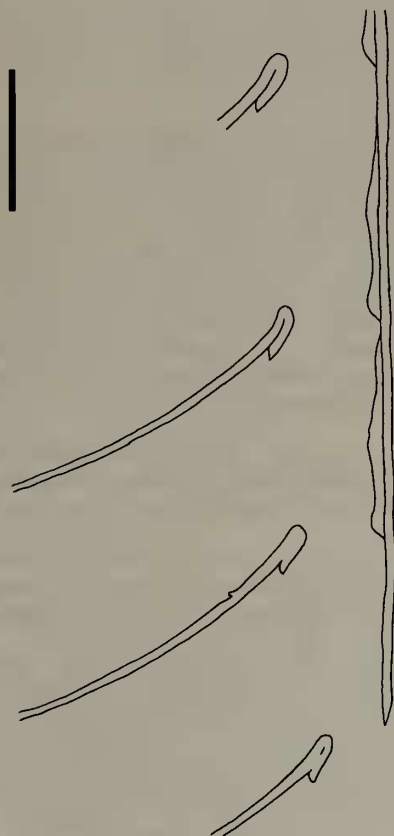


Figure 6. *Sinobactrites wuae* gen. et sp. nov., holotype, GS.C184. Camera lucida drawing of siphuncle, based on dorsoventral thin section. Scale bar=5 mm.



records of parabactritids are exceedingly rare. Previously only a single Namurian species from the Southern Urals, *Aktastioceras* sp., has been recorded (Shimanskiy, 1968).

*Etymology*.—The specific name honors Dr. Wu Wangshi, in recognition of her contributions to the Carboniferous stratigraphy of South China.

*Material and occurrence*.—The holotype, GS.C184, is an incomplete phragmocone 66.7 mm in length. The specimen was collected from Faqing.

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